7-19-1979

Progress Report for the Dairy Research Advisory Board

Various Authors

Dairy Research Advisory Board
Utah State University
NFS 202, July 19, 1979

AGENDA

9:30 Welcome: Doyle J. Matthews, Director, Agricultural Experiment Station.

9:40 Project Review:

1. Improvement of whey based pH controlled starter media. G.H. Richardson
2. Microstructure of process cheese and its relation to rheological properties. C.A. Ernstrom
3. Feasibility of using mixtures of selected single strain lactic cultures for bacteriophage control and more uniform cheese quality. G. Hong

12:15 Lunch: University Center, West Colony Room.

1:30

4. Seasonal variations in the ability of milk and whey to support the growth of selected starter bacteria. G.H. Richardson
5. Use of ultrafiltered whole milk for the production of a process cheese base with improved yield. C.A. Ernstrom
6. Use of ultrafiltered skim milk for cottage cheese production. C.A. Ernstrom
7. Comparison of milk starter, whey based pH controlled starter and acid set on the yield, quality and economics of cottage cheese production. C.A. Ernstrom
8. Projects proposed for 1979-80.
9. Budget for 1979-80.

Ernie Childs – LD Schrader
Don Mather – Kraftco
Jack Williams – Bordens
Blaine Reed – CVDA
Ernie Gold – WDCI
Roy Taylor – WGD
Chris Gardner – UDC
– UDC

CAE –
Rod Brown –
GHR –
Rayan
Gene Hong –
Wayne Gilmon –
Carl Brotherson –

USU-AES

+ WPI
Dairy
Dairy Club

IMPROVEMENT OF WHEY BASED pH CONTROLLED STARTER MEDIA

S.L. Wright and G.H. Richardson

The development of optimal media for the pH control culture system is a continuing process. Just as the best feed blends are sought for poultry and animal feeding programs, we should find the medium that efficiently produces the most cell mass with the greatest activity. This continual search is evident in traditional fermentation industries. Vinegar, citric acid and antibiotic production industries for example are still evaluating improvements in media formulations. Many media, including unmodified reconstituted non-fat dry milk solids, will support improved culture growth and activity when used with pH control. However the high level of solids used in some blends, can counter any benefits associated with pH control.

Studies were completed this year which helped establish an optimum blend of whey solids, casein hydrolyzate and yeast autolyzate in the medium used for pH controlled cultures. The computer was used to compute contour maps showing the peaks for each particular component. Experiments were conducted in which three levels of each variable were examined. Numerous test tube fermenters were operated simultaneously and culture neutralized through dropwise addition of ammonium hydroxide when the medium indicator color changed. The medium control was comprised of 5% whey solids, .5% yeast autoyzate and .1% casein hydrolyzate. This control formula was an improvement over the one we published in 1977 but was still not considered optimum. The analyzed data dictated that the optimum for cell mass production and culture activity was 5% whey solids, .7% yeast autolyzate and .4% casein hydrolyzate. An economic analysis is being conducted to optimize the cost/benefit ratio. Some claims in the literature indicate that intact casein

is essential for optimal cell characteristics. A study is now underway to evaluate the significance of this claim and the level of intact casein required.

Microstructure of Process Cheese and its Relationship to Rheological Properties

A. Rayan and C. A. Ernstrom

The purpose of this project is to examine the effect of certain processing variables on the microstructure of process cheese, and determine whether there is a relationship between microstructure and rheological properties.

Cheddar cheese between 30 and 60 days of age with a pH near 5.1 was made into process cheese calculated to contain 40% moisture, 2.4% emulsifying salt and .5% added sodium chloride. The fat content was between 50 and 51% of the dry matter.

The processing variables included type of emulsifying salt (tri-sodium citrate, disodium phosphate, tetrasoidum pyrophosphate and sodium aluminum phosphate), time in the cooker at $180^{o}F$ (0, 5, 10, 20 and 40 min) and the addition of rework cheese (10, 20, and 30%).

The microstucture of the process cheese will be examined under the scanning electron microscope. The macrostructure of selected samples will be stained with fat and protein differential stains and examined under the light microscope. The rheological properties will be measured on an MTS testing machine. These will include elasticity, tensile strength, firmness, stickiness and compressibility. Also the cheese will be tested for meltability.

During the past year considerable time was spent learning how to prepare and examine process cheese sections under the scanning electron microscope. Also special staining techniques had to be learned that enabled us to differentiate between fat and protein under the

light microscope. An MTS testing machine suitable for use on foods was purchased in cooperation with the Department of Mechanical Engineering.

At this time all the process cheese samples have been prepared and analyzed for moisture and fat. The microscopic and rheological measurements should proceed rapidly during the next few months.

Questions —
Imitation Cheese ?
X Rays on scanning micro ?
End goal ? — 1. Look at product, get objective measurements on the products. 2. Correlation between Rh properties and micro appearance. 3. Modification of structure — salt — additives — process change — prevent defect

80 instruments in field — Std Methods ?

Some slides at MIT good — some are not — feel good about slide appearance.

Feasibility of Using Mixtures of Selected Single Strain Lactic Cultures for Bacteriophage Control and More Uniform Cheese Quality

G.L. Hong, G.H. Richardson, C.A. Ernstrom
Utah State University

and

L.L. Jonas
Cache Valley Dairy Association, Utah

In the United States there is a trend to provide the cheese industry with increased numbers of culture blends of lactic organisms of unknown composition. But in other countries, such as Australia and New Zealand, the trend is toward using fewer culture blends of lactic organisms of known identity.

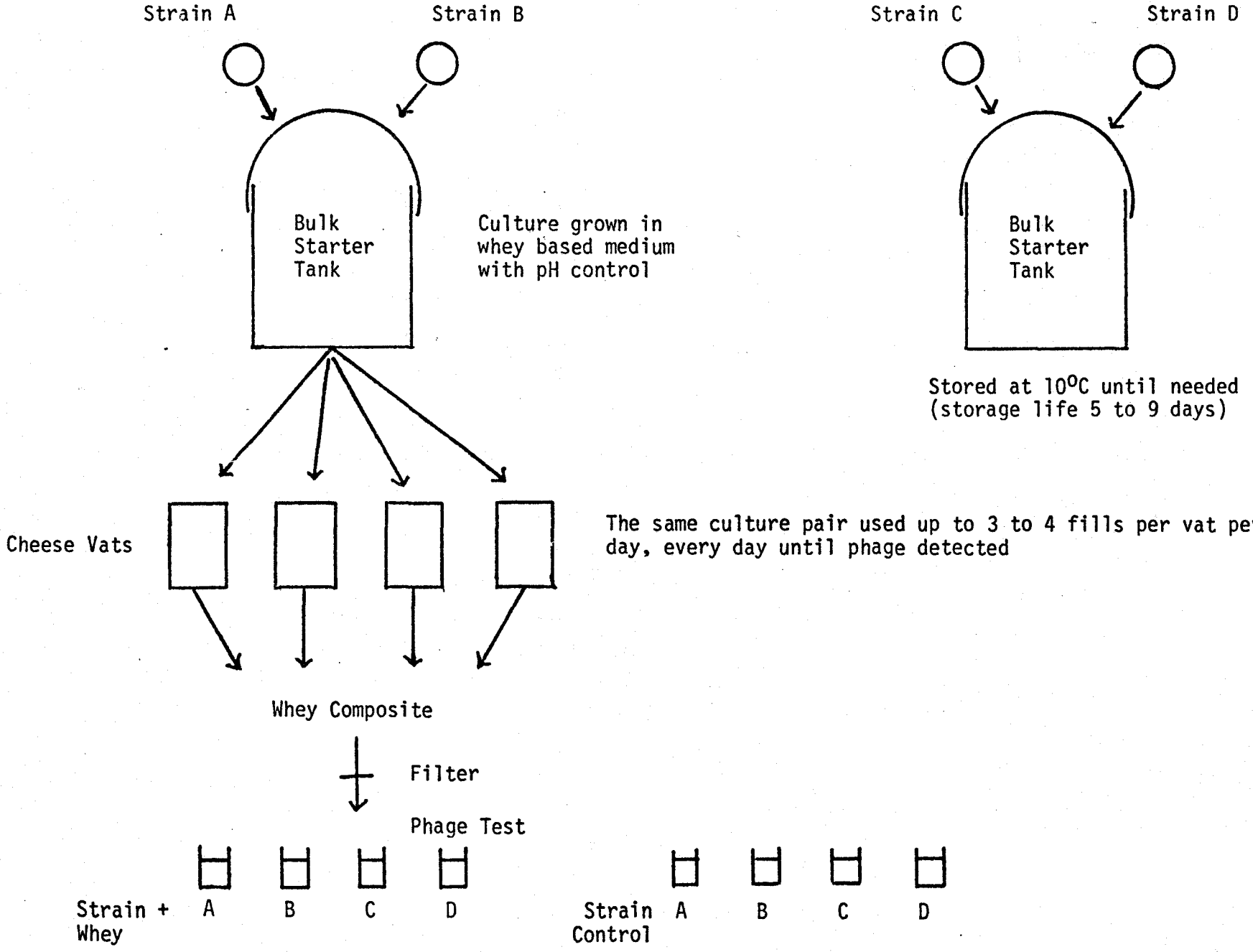
This research was conducted to determine if the quality of cheese produced at a local cheese plant would improve if fewer culture blends of known identity were used.

Lactic strains surviving the challenge of the whey composite from the cheese plant were paired so that each contained an unrelated lysogenic temperature sensitive and a temperature insensitive strain.

These lactic strain pairs were introduced into a 330,000 kg of milk/day cheese plant which manufactures cheese 7 days/week. About 145,000 kg of milk/day is processed into Cheddar and Monterey cheese. The other 185,000 kg of milk is processed into Swiss cheese.

Figure 1 illustrates the preparation of bulk starter from the paired lactic strains and the use of the bulk starter to make Monterey and Cheddar cheese.

Figure 1


Strain A
Strain B
Strain C
Strain D
Bulk Starter Tank
Culture grown in whey based medium with pH control
Bulk Starter Tank
Stored at 10°C until needed (storage life 5 to 9 days)
Cheese Vats
The same culture pair used up to 3 to 4 fills per vat per day, every day until phage detected
Whey Composite
Filter
Phage Test
Strain + Whey
A
B
C
D
Strain Control
A
B
C
D

An inexpensive bulk starter medium developed by G.H. Richardson at Utah State University that uses the cheese factory's own diluted whey with stimulants and phosphates was used to make bulk starter medium.

Two frozen bulk set cans, each can containing 100 ml of one of the selected lactic strain pair, were inoculated into sterile bulk culture medium. During fermentation of the culture medium the pH ~~is~~ was controlled at 6.1 to 6.4 at 27 to 28C. Fermentation ~~stop~~ stopped when lactose ~~is~~ was exhausted ~~or enough end products are built up to stop the bacteria from growing.~~

Bulk starter containing strains A and B ~~is~~ was used to make cheese every day until phage for either strain ~~is~~ was detected. Bulk starter containing strains C and D is the back up starter which will only be used if phage is detected for strains A or B. Because the culture is grown under pH control, the bulk starter can be stored at 10C for at least 5 to 9 days.

This cheese plant has four 10,450 kg capacity cheese vats. Twelve to 16 vats of Monterey or Cheddar cheese are made/day indicating that the same pair of lactic culture blend could be used up to three to four fills/vat/day.

Whey samples are collected daily from each vat and combined with a whey composite from the previous day. The combined whey sample is used in a simple phage test to detect for phage against each of the lactic strains used in the plant's culture rotation program.

Table 1 indicates the stability of the whey-based pH controlled grown bulk starter at 10C. An acid activity test is run on all bulk starters to determine inoculum levels and stability of the stored bulk culture. Bulk starter is stable for at least 5-9 days. We have never determined exactly how long it can be stored.

Table 2 indicates the pairs used in the two strain program. Strain

JC_2A is a resistant strain developed from strain C_2 at the cheese plant from a positive phage test tube. Notice that strains JC_2A-134 were utilized for 21 days or to make 234 vats of cheese.

One vat of cheese was made with pair ML_8-114 to determine if nine day old bulk starter would make good cheese. Then 83 more vats of cheese were made from pair JC_2A-134. The bulk starter for JC_2A and 134 started to decrease in activity. The problem was corrected by eliminating refrigerated mother cultures and supplying the cheese plant with frozen bulk sets.

Seventy percent of all Monterey cheese and 60% of all Cheddar cheese made at this plant from December 14, 1978 to May 31, 1979, were made with strains JC_2A-134.

Table 3 represents the pairs used during the last part of May. Notice phage for JC_2A appears more frequently and therefore cannot be used as long to make cheese. Strain JC_2B is a resistant strain of JC_2A developed from a positive phage test for JC_2A at the cheese plant. We have not detected a phage for strain 134 or JC_2B at this cheese plant.

Table 4 shows the average cheese make time and 24 hr pH comparisons of Cheddar and Monterey cheese made with commercial cultures and the 2 strain culture program. All cheese vats having a pH and make time at this plant are included in this data. The commercial culture program at this plant consisted of rotating 2-3 different culture blends per day, with a total of 14 different culture blends in their entire rotation program.

Notice the coefficient of variability of the cheese make time and standard deviation of the 24 hr pH of the cheese made with the 2 strain culture program is lower than compared to the cheese made with the commercial culture program.

Plant A, which uses the 2-strain culture program, procures cheese from eight other cheese plants. The age of the procured cheese is 4 to 10 days before plant A receives it. Table 5 indicates that pH of Cheddar cheese obtained from 9 cheese plants. The pH of the procurred cheese may not represent all the cheese produced at their plants. For example, cheese graders from plant A go to plant B and select the cheese they wish to purchase. Notice all the standard deviations of the pH of the procurred cheese are higher than the cheese made with the 2 strain culture program.

Table 6 indicates the percentage of Monterey and Cheddar cheese made with the 2 strain culture program and with the commercial culture program according to 24 hr pH ranges. The 2 strain culture program has a lower percentage of cheese made in pH ranges where cheese quality is questionable than compared to the commercial culture program. Notice that 36.3% of the cheese made with the commercial culture program as compared with 10.3% of the cheese made with the 2 strain program is above pH 5.31 and below pH 5.00.

Table 7 indicates the pH comparison of cheese samples obtained from 9 cheese plants. Notice plants C, F, G, H and I send 40% or more of their cheese to plant A with pH of the cheese above 5.30 or below 5.00. Cheese made with the 2 strain culture program produced a higher percentage of cheese in an acceptable pH range when compared to the other cheese plants.

Table 8 lists the advantages of the 2 strain culture program grown in whey based medium with pH control. We have demonstrated a more consistent cheese quality produced by the 2 strain culture program over this plant's commercial culture program. The reason is they are able to use a pair of lactic strains for longer periods to make cheese and they are using fewer culture blends. Therefore, we have more control in the final cheese product

using the 2 strain program. Since all strains are identified and carried individually, one strain in the pair can be matched with another strain to form a new pair. For instance, in the pair JC_2A-134, if strain JC_2A develops phage frequently, strain 134 can be matched with another strain to form a new pair.

With simple daily phage monitoring one can identify a phage problem in the laboratory before it happens in the cheese vat. This cheese plant has been able to isolate new phage resistant mutant strains from their phage test and is using them in their 2 strain culture rotation program.

Since all bulk starter is grown under pH control, stored back up bulk starter containing a different pair than being used to make cheese is always available to use if a phage problem occurs. There is also no need to make bulk starter every day. This plant does not prepare bulk starter on weekends because they make larger quantities of starter during the week, and therefore they always have extra bulk starter around.

Also plants need only 5 to 10 minutes of ripening time which allows less time for phage to come in contact with the starter. This is because the bulk starter is grown under pH control and has not been damaged by sitting in its own acid.

The whey based medium used with pH and temperature controls is inexpensive. This plant is currently saving over $100,000/year over the cost of the commercial phage inhibitory medium they were using.

Table 1. Stability of Whey-Based Controlled Grown Bulk Starter at 10 C

Culture Blend	3% Starter Activity Test pH Drop in Cheese Milk After 1.5 hr at 30°C	Days Stored at 10°C
ML_8-114	.41	1
	.32	3
	.40	4
	.48	6
	.36	7
	.31	8
	.34	9

After 9 days of storage 1.06% ML_8-114 bulk starter was used to make Cheddar cheese with five minutes of ripening time and 4 hr. 20 min. make time. The cheese grade was an A.

JC_2A-134	.29	1
	.29	2
	.31	4

JC_2A-134 stored from 1 to 6 days before making cheese.

Table 2. 2 Strain Culture Program

Culture	No. of Days Culture Used	No. of Cheese Vats Made	Strain Attacked	Day Detected
108-134	2	16	108	2
JMAAI-134	4	37	JMAAI	3
JC_2A-LMAAI	2	19	LMAAI	1
JC_2A-134	21	234		
ML_8-114	1	1	$JC_2A\pm$	1
JC_2A-134	9	83	$JC_2A\pm$	1
			$JC_2A\pm$	5
ML_8-134	2	12	ML_8	1
JC_2A-134 bulk starter slowed down, corrected by using frozen bulk sets instead of refrigerated mother cultures.				
104-266	4	40		
JC_2A-134	7	105		
104-266	3	18	104	2
JC_2A-134	8	87	$JC_2A\pm$	7

Table 3. Two Strain Culture Program

Culture	No. of Days Culture Used	No. of Cheese Vats Made	Strain Attacked	Day Attacked
JC_2A-134	4	34	C_7 JC_2A	3
108-JC_2B	1	7	C_7 C_7	
JC_2A-134	3	23	JC_2A	3
108-JC_2B	2	14	108 108	2
C_7-JC_2B	2	12	$C_7\pm$	2
108-JC_2B	1	6	108	
JC_2A-134	3	27	108±	
C_7-JC_2B	2	15	C_7	1
JC_2A-134	5	54	$JC_2A\pm$	5

Table 4. Cheese Make Time and 24 hr pH Comparison of Cheddar and Monterey Cheese Made with Commercial Culture Program and 2-Strain Culture Program

2 Strain Culture Program

December 14, 1978 - May 31, 1979

	No. of Vats	Cheese Make Time		24 hr pH of Cheese	
		Min.	CV	pH	SD
Monterey	952	143	7	5.16	.12
Cheddar	1097	238	8	5.19	.09

Commercial Culture Program

December 14, 1977 - May 31, 1978

	No. of Vats	Cheese Make Time		24 hr pH of Cheese	
		Min.	CV	pH	SD
Monterey	990	164	12	5.10	.20
Cheddar	1422	219	11	5.20	.19

Table 5. pH Comparisons of Cheddar Cheese Samples Obtained from Nine Cheese Plants

	2 Strain Culture Program	Commercial Culture Programs							
Plant	A	B	C	D	E	F	G	H	I
No. of Cheese Samples	1097	163	49	44	73	60	19	92	15
Mean pH	5.19	5.08	5.27	5.09	5.20	5.14	5.10	5.09	5.13
Standard Deviation	.09	.13	.17	.16	.17	.25	.17	.16	.14

Table 6. Comparison of Cheese Made with Commercial Culture and 2-Strain Culture Program According to Selected 24 hr pH Ranges

	Commercial Culture		2-Strain Culture
No. of cheese vats	2398		2096
	----	(% Cheese)	----
above pH 5.4	8.6		2.2
pH 5.31 - 5.40	10.1		4.5
pH 5.30 - 5.21	18.5		33.8
pH 5.20 - 5.10	27.9		38.5
pH 5.09 - 5.00	17.3		17.4
pH 4.99 - 4.90	11.9		3.3
below pH 4.89	5.7		0.3
above 5.31 and below 5.00	36.3		10.3

Table 7. pH Comparison of Cheese Samples Obtained from Nine Cheese Plants

Cheese Plant	2-Strain Culture Program	Commercial Culture Programs								
		A	B	C	D	E	F	G	H	I
Cheese between pH 5.00 - 5.30	89.7%	63.7	71.8	57.2	72.7	68.4	50.9	52.7	53.3	60.0
Cheese above pH 5.31 and below pH 5.00	10.3%	36.3	28.2	42.8	27.3	31.6	49.1	47.3	46.7	40.0

Advantages of 2 Strain Culture Program
Grown In Whey Based Medium With pH Control

1. More consistent cheese quality.
2. All strains in the pairs are identified and carried individually.
3. Detection of a phage problem in the laboratory before it happens in the cheese vat.
4. Isolation of phage resistant mutant strains from the phage test.
5. Back up bulk starter always available. (Storage life 5-9 days).
6. No need to make bulk starter every day.
7. Less ripening time (5 to 10 minutes).
8. Whey based medium is inexpensive.

SWISS CHEESE MADE WITH WHEY-BASED pH CONTROLLED LACTIC CULTURES

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G.L. Hong, C.A. Ernstrom and G.H. Richardson

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We have published laboratory studies on the use of the pH control concept for the propagation of the rods and cocci used in the production of Swiss and Italian cheese varieties. This work is the first associated with the incorporation of the Utah State University Lactic Culture System in a commercial Swiss cheese application. A conventional bulk culture tank was fitted with pH and temperature instrumentation and controls. Six blends of Streptococcus thermophilus were obtained from commercial sources and propagated in the same medium used to culture lactic streptococci for American cheese production. However, the temperature was controlled at 37C instead of 27C. Lactobacillus bulgaricus strains were propagated in a ten gallon can without pH control. Laboratory studies have confirmed that they can be propagated under pH control if desired.

Upon completion of the growth cycle and consumption of the fermentable carbohydrate, the culture was chilled to 10C and stored 4 to 7 days before being completely utilized. Daily activity and phage monitoring tests were conducted to thwart any potential problems before they could cause concern in the plant. One of the culture blends did not grow well in the medium which suggested that further medium modification might be needed for this application. The other five blends developed well in the medium and were used to inoculate the cheese vats at down to one tenth the normal volume. This was possible because of the marked improvement in cell numbers and activity. When inhibited activity suggested phage build up two blends were removed from the rotation scheme.

Over 500 vats of cheese have been made with the whey based medium under pH control and compared with over 1400 vats made with conventional whole milk culture. The pH means and standard deviations were 5.29 $\pm$ .09 and 5.30 $\pm$ .10 respectively indicating no significant difference in acid development in the Swiss cheese. Two hundred sixty vats of cheese made with whey culture were compared at the time of grading to 524 vats made with milk culture. The former produced 94% A & B grades while the latter produced 88% A & B grades. There was no quality loss through the incorporation of the whey-based pH control concept in Swiss cheese manufacture.

Each bulk culture tank held 2805 pounds of bulk starter and could inoculate 80 to 129 vats of milk depending upon the activity of the culture blend. The bulk culture could be used from 4.5 to 7 days whereas the milk culture was used up in only one half day. The cost of ammonia and dry ingredients added to the fresh liquid whey varied from 79¢ to $1.26 per vat. Labor and culture preparation costs would be reduced since each bulk tank need be prepared only one time in four to seven days. This would obviously vary from plant to plant but weekend culture preparation became a thing of the past with this program. There were no over or under ripened bulk starter problems that were associated with whole milk cultures.

July, 1979

The Utah State University Lactic Culture System

by

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The Utah State University Lactic Culture System combines the use of conventional bulk culture tanks, pH and temperature controllers, and diluted fresh liquid whey containing stimulants and phosphates/citrates. In this system more bacteria are produced, they are more active and can be stored for days, thus eliminating the need for daily lactic culture propagation. The system has been demonstrated to have many economic advantages for the cheese industry over conventional culture systems.

EQUIPMENT AND SUPPLIES

CULTURE TANK. Sealed culture tanks are best, however, they are not readily available in the United States. For this reason it is necessary to atmospherically isolate tanks and incorporate citrates or phosphates in the media to minimize the effects of bacteriophage (phage) infection. The tank should provide slow speed agitation throughout the culture fermentation cycle. The tank must be equipped with pH and temperature controllers.

PH ELECTRODE AND CONTROLLER. The Ingold[a] electrode has been used in the fermentation industry for years and also has proven very reliable in the lactic culture industry. It can withstand steam sterilization

[a]Mention of products or companies does not constitute an endorsement by Utah State University over products of a similar nature not mentioned.

pressures and temperatures and can be cleaned in place. A typical electrode has been used for over eight months of continuous daily culture preparation, then cleaned and replaced. The electrode is connected to a pH controller that records a pattern indicating culture growth and activity. Alarms can be placed upon the controller that will place telephone calls ~~or~~ and notify plant personnel of equipment failure. Equipment and supplies are available from commercial sources.[b]

AMMONIA GAS AND VALVES. Refrigeration grade anhydrous ammonia has specifications that exceed those required for Codex Alimentarius Food Grade ammonium hydroxide and therefore meets the Generally Recognized As Safe status of the Food and Drug Administration for this application. This gas is available at most dairy plants and can be readily used to neutralize the acids formed during the culture fermentation. A pressure reduction and venting system should be attached to the gas tank. The gas then passes through stainless steel tubing to a three way solenoid valve operated by the controller. The valve allows ammonia gas into the culture tank when activated. A 1" or larger ID pipe conveys the gas below the culture ~~A~~ When inactivated, the valve restores atmospheric pressure in the tubing to prevent the culture from backing up into the ammonia lines and valving.

TEMPERATURE CONTROLLER. The streptococcal cultures for American and cottage cheese production are propagated at 27C. Ammonia gas generates heat of solution upon injection and causes the culture temperature to rise. It is thus necessary to incorporate a temperature sensor into the culture tank and include an automatic water control valve in the tank cooling system. Whenever the temperature increases, the valve is opened and the culture is automatically cooled to 27C. The organisms used in Swiss and Italian cheese production need control at higher temperatures.

[b]Biolac Inc., 745 East 50 North, Logan, UT 84321 (801) 752-6820.

MEDIUM. Fresh liquid whey is the most readily available and economical source of energy for the propagation of lactic cultures at the cheese factory. Phosphates and some nitrogenous materials are necessary adjuncts to make the medium inhibitory to phage development and provide maximum stimulation for the cultures. The whey must be diluted with water to reduce lactose levels in the medium. This is because all the sugar is fermented to lactate ion during the cycle and this ion is toxic to the cells. By diluting the lactose it is possible to get the maximum growth of cells and avoid the buildup of toxic end products.

CULTURES. Any source of lactic cultures that has proven workable to inoculate bulk cultures in the cheese plant will work with the Utah State University Lactic Culture System. Improved cheese quality has been reported through the use of identified pairs or blends of single strains of streptococci.

PROCEDURE

1. Pump sufficient fresh liquid whey and water into the bulk culture tank to result in a 3.75% lactose solution and commence agitation.
2. Add ten pounds of phosphate/stimulant blend per hundred gallons of medium. Assure the mixture is above pH 6.2 through ammonia injection if necessary.
3. Standardize the pH control system following warm up by noting the pH reading on the medium. Withdraw a sample, check the pH of the medium on a laboratory meter and adjust the controller reading accordingly. Then turn off the controller until the heating-cooling cycle is over.
4. Heat the entire contents to 90C and hold for 45 minutes.
5. Cool the medium to 27C and inoculate the culture through a steam ring or similar protective inoculation system.
6. Activate the pH control system. The phosphates in the system provide buffering which can be used to check operation of the pH instrumentation at startup. Set pH controls at 6 and allow sawtooth trace development from 6 to 6.2 on the chart. Set high and low alarms at pH 7 and 5.8 respectively.

7. The culture cycle should be complete in 14-20 hours. It can then be used without cooling throughout the day or cooled and pumped into storage tanks for subsequent utilization.

8. Inoculate cheese milk at 10 to 40% of normal volumes depending upon previous history of the culture in the plant.

MOST FREQUENTLY ASKED QUESTIONS CONCERNING THE UTAH STATE UNIVERSITY LACTIC CULTURE SYSTEM

WHAT ARE THE ADVANTAGES OF THE SYSTEM?

-Lower cost than associated with conventional phage inhibitory media systems.

-Greater culture activity and end product uniformity.

-Bulk cultures don't need to be prepared daily or over weekends.

-Standby cultures can be held to back up the blend in daily use. Fewer blends can be employed with less concern for phage buildup.

-Cultures don't need the ripening periods in the vats which have been characteristic of frozen ~~direct to vat~~ directly set programs.

-There are more bacteria per volume of medium.

-The cultures never gets sour.

-No phosphates are required in protected equipment. Lower phosphates are required in unprotected equipment, thus cultures are more active. Also, there is less adverse effect upon the calcium chloride added to milk for curd firmness improvement.

-Cultures have less pH adjustment lag than conventional "sour" cultures when added to the cheese milk vats.

-Ingredients are instantly soluble.

-Energy nutrient source (lactose) is most readily available and economical. It doesn't have to be condensed, dried and shipped from other areas at great expense.

WHAT ARE SOME SPECIFIC ECONOMIC ADVANTAGES?

There are advantages for cheese plants of all sizes to consider this system. Plants with only 60,000 lb per day estimate savings of $16,000 per year. Plants now on the program save from $100,000 to $~~300~~,000 per year over the costs associated with conventional phage inhibitory media programs. The capital equipment costs can be recovered in a few weeks or days.

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BUT WE WILL GET LOWER YIELDS, WON'T WE?

It is true that there is no casein to produce cheese though the whey protein yield value is unchanged. Heated casein is not the best cheese yielding substance, therefore it is suggested that the casein be put into the cheese vat, unheated, for maximum yield advantage. This would allow the culture tank to produce active bacteria--not cheese.

HOW CAN CULTURES PERFORM NORMALLY WHEN THERE IS NO CASEIN IN THEIR ENVIRONMENT?

Hydrolyzed casein or whey protein is included in the stimulatory nitrogenous material included in the medium. Cultures propagated in this medium have performed better in the vat due to the pH being closer to that of the milk and there is a greater number of cells. There is no need for a ripening interval before rennet addition. Cheese held during extended curing has been normal in every respect.

WHY IS THE CULTURE MORE ACTIVE AND LESS IS NEEDED?

Because there are 2 to 5 times the numbers of active cells per volume than with conventional cultures. They are more active because they do not have to adjust to as great a pH shock when added to cheese milk. They go from pH 6 to pH 6.6 instead of from pH 4.7 to pH 6.6. They also go to the same predictable endpoint each day due to the limited lactose whereas conventional cultures are "somewhere along the way" at the time they are used.

WHY ARE THEY MORE STABLE DURING STORAGE?

The lactose is all used up and there is no way the bacteria can produce more acid during storage. The storage pH thus remains near 6 and the adverse effects associated with high acidity are avoided. The pH controlled cultures have kept normal activity during refrigerated storage for forty days depending upon the blend of strains in the culture.

Cultures may be held at 4 to 13C for at least a week as reserve culture in the event of phage buildup against the culture in daily use. The culutre can be used even after considerable activity loss--though at higher inocula levels.

WHAT IS THE NORMAL CULTURE CYCLE TIME?

Cultures will vary depending upon the inocula volumes used and the strains involved. However, cultures incubated at 27C are ready to use in an average of 14 to 20 hours. Remarkable stability allows them to be held without cooling so a culture can be used for over 24 hours without activity change.

HOW CAN YOU POSSIBLY ADVOCATE USING WHEY FROM MY OWN PLANT IN VIEW OF IN PLANT PHAGE CONTAMINATION?

No phage can survive the 90C for 45 minute temperature treatment given the medium prior to cooling and inoculation. The phage would be

just as "dead" as if it came into the plant via dry whey powder which had been processed in another plant thousands of miles away.

BUT WHAT ABOUT THE INHIBITORY SUBSTANCES THAT SOME STRAINS PRODUCE IN WHEY THAT COULD AFFECT SUBSEQUENT LACTIC ORGANISMS GROWING IN THE WHEY?

Most mixtures of the lactic strains used in cheese production prove stimulatory when grown together. This stimulation would occur when the strains follow each other in the same medium just as it does when they grow side by side.

WHEN PH CONTROL IS USED ISN'T THERE MORE POTENTIAL FOR THE GROWTH OF CONTAMINATING ORGANISMS?

Contaminants don't compete well with lactic organisms when propagated either with or without pH control. The lactic streptococci have better activity under pH control. Staphylococcus organisms inoculated into the pH controlled cultures were unable to grow or produce toxin when active lactics were present. Coliforms and perhaps some other organisms can grow in competition with lactic streptococci. ~~Just think of the numbers that might slip off the fingers of the inoculator who carelessly handles the culture compared to the billions of cells of active lactics added simultaneously! Contaminants don't stand a chance unless the tanks are improperly cleaned and protected.~~ Several plate count surveys have produced data to confirm that there is in practice less of a problem with contaminants in the pH control system than with conventional bulk cultures. This is probably due to the "healthier" lactic organisms. We need be more concerned about phage contamination.

DOESN'T STRAIN DOMINATION OCCUR MORE RAPIDLY WHEN PH CONTROL IS USED?

Yes. The pH control shortens bacterial generation times thus producing more cells in a shorter time. Thus, if dominance will occur in a conventional blend due to an imbalance of strains at inoculation, this dominance will occur earlier. This is being minimized through inoculation of single strains in known proportions.

WHAT HAPPENS IF THE SYSTEM FAILS?

There are built in alarms in the control equipment. For the first time in history plants have a means of knowing culture activity and have an indication of inadequate growth through the recorder tracing. If the ammonia valve sticks and too much gas gets into the tank a dead culture will result and back up blends must be used. If the ammonia feed system fails then the pH will drop to normal levels and the culture will have the same activity characteristics as a conventional culture and can be used accordingly. The reliability of the currently available electronic pH equipment is such that very few failures have been encountered. The overall benefits far outweigh the problems noted through equipment failures.

CAN THE SYSTEM BE USED FOR ALL TYPES OF CHEESE?

There are over nine years of plant field experience where American style cheeses have been manufactured. It has also been successfully used

in cottage cheese production with over one year experience, where inocula levels of 2% produce normal short set cutting times. There has been over six months plant experience using the system for Swiss cheese production, and inocula levels have been one tenth that of normal requirements. One culture tank inoculates 120 vats instead of 13. Only the high temperature cocci have been so propagated in the factory, however, laboratory work at USU has demonstrated that the rods also perform satisfactorily under pH control. Their balance would have to be monitored carefully if propagated together. Though there has been no plant experience with Italian cheese there is a greater economic potential here because of the higher levels of starter used. There is little application for the pH control system in sour cream, buttermilk, yogurt or cream cheese production.

DOESN'T WHEY TAINT OR OTHER OFF FLAVOR PROBLEMS DEVELOP IN ANY CHEESE VARIETIES?

No off flavors were noted even when 5% culture was used in cottage cheese. In American style cheese we are in effect adding .4 to 1.0% spent lactose whey to 90% whey by-product from the manufacture. No flavor problems have been reported and tons of cheese are made daily. Whey solids are now used in many of the inhibitory media on the market without flavor defects. Fresh whey should have fewer potential flavor problems than processed whey.

I AM TOLD THAT WE SHOULD HAVE SCIENTIFICALLY TRAINED PERSONNEL IN THE PLANT BEFORE TRYING THIS SYSTEM.

Many of the units now in the field are operated in small plants by personnel with minimal training. The system requires no more technical ability than other operations associated with cheese making.

CAN I USE THE SAME INOCULATION VAT AFTER VAT?

Any culture system requires adjustment of the inocula volume depending upon the activity of the strains involved. This system has, however, made that volume more uniform and the final product acidity more uniform.

WHAT ARE THE ADVANTAGES OF HAVING A LOWER PHOSPHATE CONTENT WITH THE SYSTEM?

Calcium is dissolved as acid develops in a conventional culture. The calcium is released from insoluble salts. Thus high phosphate levels are required in phage inhibitory media to keep the calcium low and thereby prevent the phage from attaching to the bacterial cell wall. When the pH is controlled less calcium is released, therefore ~~less~~ phosphate is needed to provide the same protection. There is also less calcium in the whey than in milk based media. Calcium chloride can legally be added to cheese milk and can have a greater effect upon curd quality when fewer phosphates are added via the culture. Milk coagulation also occurs more rapidly with fewer phosphates.

IF YOU PROVIDE ALL THOSE STIMULANTS ~~IN~~ TO THE MEDIUM HOW DO THE CULTURES PERFORM WHEN TRANSFERRED TO MILK?

Great! (All special culture media on the market for the past 15 to 20 years contain stimulants.)

WHY USE THE PARTICULAR STIMULANT BLEND DESCRIBED?

Any culture medium including milk will produce more active culture when under pH control. It is a matter of efficiency, predictable culture activity and storage stability. We feed poultry and animals blends of feeds to assure maximum growth and production. Why not give bacteria the same opportunity? The culture medium recommended has been formulated during ten years of research and using computer coupled projects. Phosphates are suggested for phage protection only if bulk culture tanks are open to the atmosphere.

WHAT ARE THE TYPICAL USEAGE LEVELS FOR THE INGREDIENTS IN THE SYSTEM?

The fresh liquid whey would be diluted to about 3.5 to 4% lactose. The phosphate stimulant blend would be added at about 1.2% and the amount of ammonia used for a cycle would amount to approximately 1.6%.

WHY DO YOU ADVOCATE ANHYDROUS AMMONIA GAS INSTEAD OF AMMONIUM HYDROXIDE, CAUSTIC SODA OR SOME OTHER NEUTRALIZER?

Ammonia is less toxic to the cells than some other neutralizing substances. It is readily available, easy to handle at the plant and can be obtained in large storage tank quantities. A solution of ammonia (ammonium hydroxide) would prevent the need for the temperature controller on the culture tank but would require the handling of an additional product at the plant. Sodium hydroxide has been suggested however this is more difficult to handle and sodium ions are much more toxic to the bacterial cells than ammonium ions.

The statements made in this report are supported by over ten years of research at USU, the New Zealand Dairy Research Institute, and in cooperating cheese plants and industry laboratories. Reprints containing the scientific data are available upon request. Please write to:

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or call (801) 752-4100 Ext. 7691 for response to any unanswered questions.

SEASONAL VARIATIONS IN THE ABILITY OF MILK AND WHEY TO SUPPORT THE GROWTH OF SELECTED STARTER BACTERIA

R.C. Norton, C.A. Ernstrom and G.H. Richardson

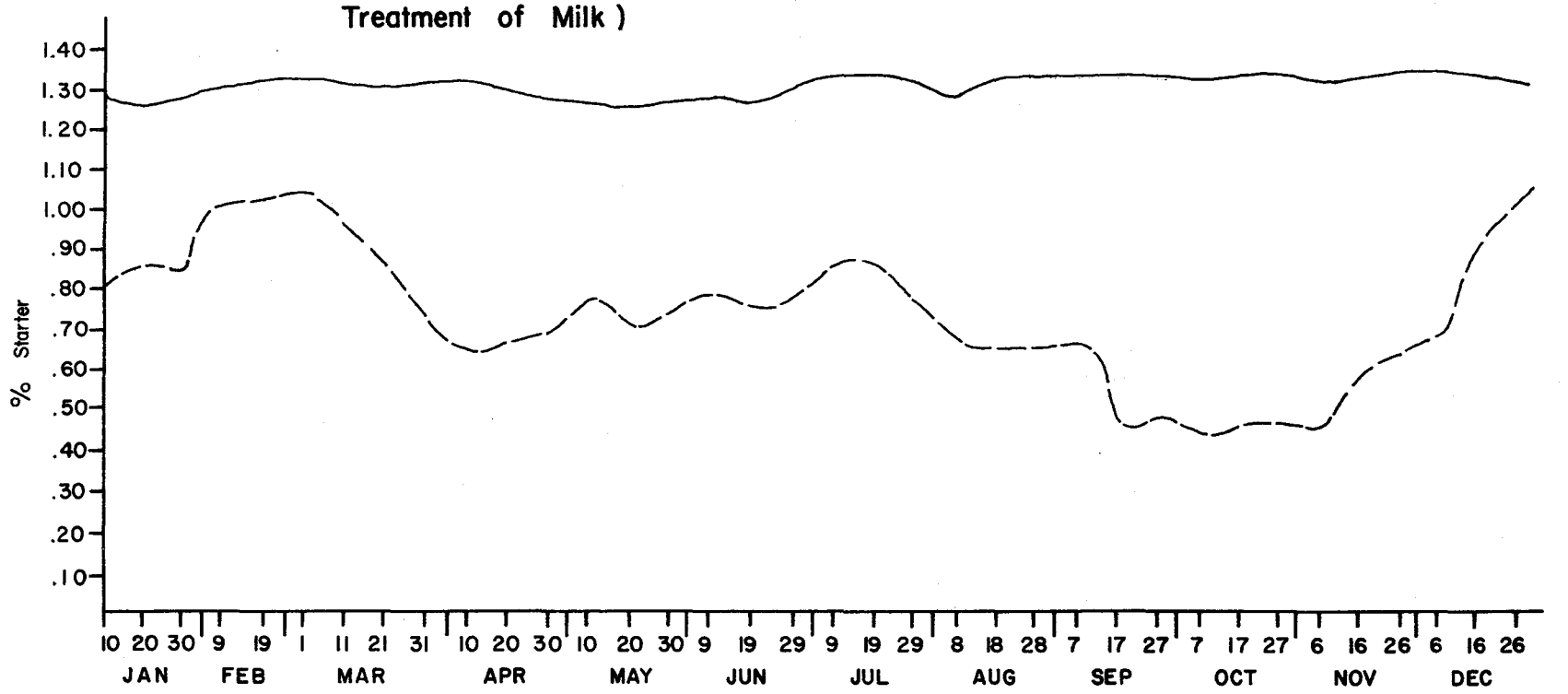
Unexplained variation still exists in the ability of lactic organisms to develop in milk for cheese making. Though there is great effort to standardize the medium, inoculation and incubation conditions associated with the production of bulk culture, daily or hourly variations in culture performance are noticed in the vats. The obvious variations are associated with explainable modifications of the make procedures or the presence of antibiotic substances. Less obvious are seasonal changes that occur in the ability of the milk to support the growth of lactic organisms thus requiring incorporation of more starter during certain periods of the year. This is of added concern to the plants using whey-based media. Inhibitory substances naturally present in the milk, may also carry over into the whey used for culture propagation. It is also of concern that such inhibition might not be overcome through the nitrogenous stimulatory substances added in the make up of the medium or that it might not be inactivated during heat treatment of the medium prior to inoculation.

Annual starter addition records were obtained from two local plants. The plant which used a vacuumization treatment of the milk seemed to have much more uniform inocula throughout the year. The mean at the plant without vacuumization varied from .4% to 1.05% with the low inocula season during the fall (Fig. C). It was decided to examine the milk from a common source throughout the year and note what seasonal changes could be detected.

Raw, pasteurized and vacuumized milk is obtained every two weeks from the plant using vacuumization. Both samples are returned to the laboratory

C DAYS vs % STARTER

(Comparative Results of Vacuum and Non-vacuum Treatment of Milk)



where a portion of the raw milk is pasteurized and a third portion is renneted to produce sweet whey. The raw milk is screened for abnormality using the Wisconsin Mastitis Test (WMT). An activity test is conducted using selected strains of lactic cultures which have been freeze dried and transferred once before the test. Both pH and titratable acidity changes during 3.5 hours at 30C are recorded. Sterilized reconstituted non-fat dry milk is also used as a control in the activity test. A portion of this substrate is also renneted for the whey control substrate. The following tests are conducted on the samples indicated:

WMT-raw milk

Activity - raw, pasteurized, vacuumized/pasteurized and sterile NDM.

pH control substrate (with no added stimulants or phosphates) - whey from raw, pasteurized/vacuumized and sterile NDM.

The ability of the organisms to grow in whey which contains no added stimulants should give an indication of any hold over inhibitors which would adversly affect their activity when propagated in whey. If an indication of inhibition is observed, then the ability of the stimulant blend to overcome this will be evaluated.

The results to date are inconclusive. Marked differences should appear starting in September when the low inocula season peaks. The high inhibition season will be reached around the first of the year and methods of overcoming this effect will be examined at that time.

Use Mfg Grade milk. Diff due to milk quality not mac treat. Grade A milk used in COW

USE OF ULTRAFILTERED WHOLE MILK FOR THE PRODUCTION OF A PROCESS CHEESE BASE WITH IMPROVED YIELD

D. HWANG AND C.A. ERNSTROM

Work on this project was reported at last years meeting when it was shown that a potential existed for making a process cheese base from ultrafiltered whole milk. The base contained 36% moisture and gave about 18% greater yield than normal Cheddar cheese with the same moisture content. Yield data that were presented last year are shown in slide 1.

Process cheese was made from the base by blending 80% base with 20% aged Cheddar cheese. It processed well but the body was flinty and the cheese did not melt well.

The major objective of the current work is to increase the body break down of the process cheese base or the ultrafiltered retentate in an effort to improve the body characteristics of the process cheese.

During this past year we have directed most of our attention to acquiring the appropriate equipment for this work. We now have two Patterson-Candy ultrafiltration modules and the necessary pump and piping for their operation.

Considerable difficulty was encountered in finding a suitable swept surface vacuum evaporator. We can now report that a small 20 quart batch unit should be delivered in September 1979. It is recognized that a continuous evaporator will be required for commercial production. A test was run on a continuous vacuum evaporator built by the Groen Corp. in Chicago, but it was quickly learned that substantial changes would be required before it could successfully handle the type of material we are dealing with. We chose to purchase a small batch evaporator with which we believe we can generate sufficient data to show the potential

of the UF process cheese base. Development of suitable equipment would then require a cooperative effort between equipment manufacturers and the cheese industry.

While searching for evaporation equipment several experiments were conducted with the ultrafiltration modules.

In the report last year we indicated a substantially lower permeation rate with acidified (pH 5.7) than with sweet milk (slide 2). At that time we attributed this difference to a pH induced change in the nature of the secondary membrane established by the product on the inner suface of the polysulfone membranes. We now know that this is not necessarily true because the permeability of water through the polysulfone membrane is markedly affected by pH. The lower the pH the slower the permeation.

Ten replicate experiments have been completed in which whole milk was acidified to pH 5.7, ultrafiltered and diafiltered to a composition of approximately 20% fat, 60% moisture and .6% lactose. The material was divided into three lots and inoculated with each of 3 different lactic cultures. After the residual lactose was consumed and the pH reached 5.1-5.2 the samples were packaged under vacuum and stored at 25 and 30C for 2 and 4 weeks.

The samples were evaluated for protein breakdown by measuring soluble nitrogen and were subjected to taste panel evaluation for the detection of abnormal as well as normal cheese flavor development. The experimental work has been completed, but the data are not yet analyzed. However, it can be stated that the strain or blend of starter used as a fermentation agent had a very marked effect on the quality and intensity of flavor developed in the ultrafiltrate slurrys.

Find a use for permeate.

Use of Ultrafiltered Skim Milk for Cottage Cheese Production

R. Narasimhan and C. A. Ernstrom

The concentration of milk proteins by ultrafiltration (UF) for cheese making is a commercial practice in Europe for several high-moisture cheese varieties. The advantage over conventional cheese processes is a substantially improved yield.

Our study was related to the application of ultrafiltration to skim milk for the manufacture of cottage cheese. Good quality cottage cheese has been made from skim milk ultrafiltered to a concentration of 13.1% solids (Mattews, et al., 1976), but no yield advantages were reported. Retentates with this composition would still undergo substantial synersis during cooking and would be expected to lose a good deal of the soluble whey proteins that were concentrated in the retentate.

These studies compared yields and quality of cottage cheese made by direct acidification (HCl method) and conventional culture methods from regular skim milk and ultrafiltered retentates containing 16 and 20% total solids. Manufacture of cottage cheese from retentates in excess of 13% total solids resulted in too much curd per unit volume in the vat. This made it difficult to agitate and cook the curd because there was not enough whey expelled to provide a vehicle for curd movement. In these experiments the problem was overcome by acidifying ultrafiltration permeate to pH 4.7 with lactic acid and adding it back to the freshly cut curd at the rate of 4 pounds per 10 pounds of initial retentate. This provided sufficient liquid to agitate and cook the curd by the usual vat process.

Another problem encountered in the production of cultured cottage cheese was a slow change in pH during fermentation. Figure 24 shows the pH change in skim milk and various retentates at 32.2C following inoculation with 5% milk culture of S. lactis C2. Retarded acid productions in retentates was partly due to the increased buffer capacity of UF retentates over regular skim milk. However, another factor was found to contribute to slow acid production below pH 5.0. During ultrafiltration the colloidal (insoluble) calcium phosphate in skim milk is concentrated along with the protein. When acid is later developed through the action of microorganisms the calcium phosphate goes into solution, but at a much higher concentration than would be found in cultured skim milk. Our studies revealed that the concentration of soluble phosphates that existed in 16 and 20% retentates significantly inhibited the growth of lactic cultures below pH 5.0. This is illustrated in Table 14. The higher the solids content in the retentate, the greater the inhibition. Prior to reaching pH 5, acid production in terms of milliequivalents per hour was actually greater in the retentates than in the control skim milk but upon reaching pH 5.0 the rate of acid production dropped precipitously. The problem of setting time was partially overcome in our experiments by using highly concentrated cultures (See Table 15).

Cultured Cottage Cheese

All experiments were carried out on 10 pound lots of skim milk and retentates.

Control cottage cheese from skim milk was inoculated with .4% M.D. Supertart cultures and rennet at 1 ml 1000 pounds. The curd was cut at pH 4.7 after 5 hours and cooked to 130^{o}F.

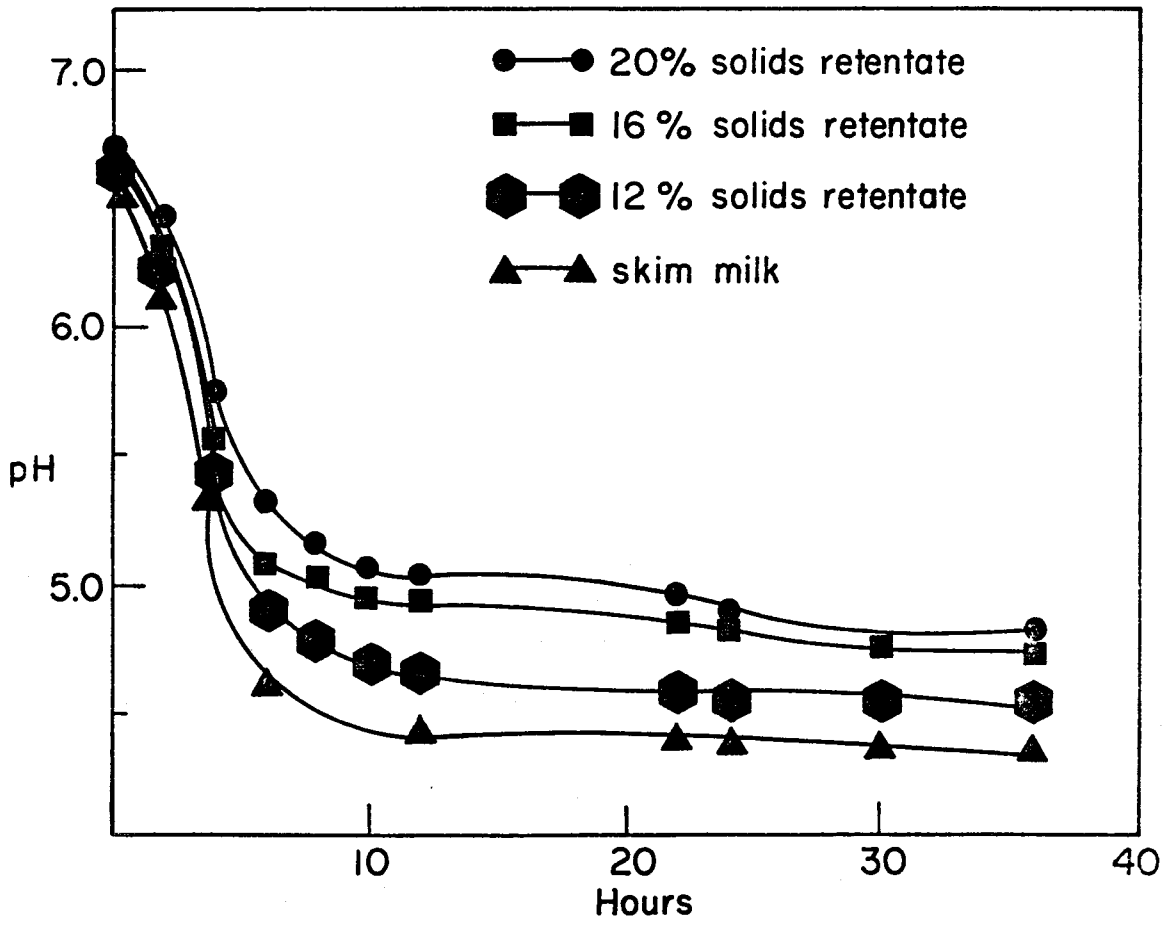


Figure 24. Relationship between pH and fermentation time during lactic fermentation of skim milk and retentate at 32.2 C.

Table 14. Rates of acid production in milliequivalents lactic acid per hour during lactic fermentation of skim milk and retentates.

pH range	Skim milk	Retentate 12% solids	Retentate 16% solids	Retentate 20% solids
	(meq/h)	(meq/h)	(meq/h)	(meq/h)
6.50-6.0	0.20	0.34	0.50	0.53
6.00-5.50	0.75	1.14	1.62	1.80
5.50-5.00	1.20	0.93	0.66	0.43
5.00-4.81	0.27	0.48	0.06	0.09
4.81-4.72	0.20	0.08	0.03	0.00

Table 15. pH and incubation time during fermentation of 20% solids retentate by Marschall Superstart LA_1.

Incubation time	Level of starter		
	(%)		
(h)	5	1	.1
0	6.56	6.56	6.56
2	4.96	5.30	6.19
4	4.81	4.92	5.53
5	4.75	4.85	5.44
6	4.74	4.85	5.39
8	4.69	4.79	5.35
11	4.64	4.73	5.07

Retentates at 16% solids were inoculated with 2% M.D. Superstart culture and .5 ml rennet per 1000 pounds. The curd reached a pH of 4.7 in 6-7 hours when it was cut, treated with acidified permeate and cooked to 130°F.

Retentates at 20% solids were inoculated with 1% M.D. Superstart culture and .25 ml rennet per 1000 pounds skim milk. The time required to reach pH 4.7 varied from 12 to 16 hours after which the curd was cut, treated with acidified permeate and cooked to 130°F.

Direct Acid Cottage Cheese

Retentates containing 16% and 20% solids were cooled to 39°F and acidified to pH 4.6 with concentrated hydrochloric acid, warmed quiescently to 32.2 by electrical resistance heating and cut. Following addition of acidified permeate, the curd was cooked to 140°F.

Yields

Cottage cheese yields were based on three applications and calculated to a standard 80% moisture. The yields are illustrated in Table 31. Direct acid and cultured cottage cheese from 16% UF retentate averaged 15.32 and 12.40% greater yields than the control. Direct acid and cultured cottage cheese from 20% retentates averaged only 1.58 and 5.63% greater yields than the control. The smaller yield increases from 20% retentates were due to substantial shattering during curd handling and cooking. The whey was always extremely milky. The analysis of variance of yields is given in Table 36.

Curd Quality

Quality ratings for the cottage cheese samples were based on the average ratings of 5 independent judges. The rating scale was from 1 to 5 in which 1 was excellent and 5 unsaleable. The results are shown in Table 37.

Table 31. Yield of cottage cheese made from skim milk and retentates by culture and direct acidification.

	Skim milk cultured (control)	Cottage cheese			
		16% retentate		20% retentate	
		cultured	direct acid	cultured	direct acid
Recovery from skim milk					
solids (%)	32.47	36.54**	37.45**	34.31	32.97
protein (%)	75.87	82.37*	84.97**	79.18	76.40
yield					
curd at 80% moisture (%)	15.37	17.27**	17.71**	16.23	15.60
increased yield over control (%)	--	12.40	15.32	5.63	1.58

*Significantly different from the control at 5% level
**Significantly different from the control at 1% level

Table 36. Recovery of solids from retentate into cheese.

Source	Df	S.S.	M.S.	F
Total	11	489.370	--	--
Replications	2	88.548	44.274	16.247**
Treatments	3	384.370	128.123	46.726**
Type (cultured vs direct acid)	1	1.477	1.477	0.539
Level (16% vs 20%	1	369.075	369.075	134.601**
Type X Level	1	13.818	13.818	5.039
Error	6	16.452	2.742	--

*Significant at 5% level

**Significant at 1% level

Table 37. Quality of cottage cheese made from skim milk and retentates by culture and direct acidification.

Quality Scores	Cottage cheese				
	skim milk cultured (control)	16% retentate		20% retentate	
		cultured	direct acid	cultured	direct acid
Flavor	2.23	2.40	2.67	2.83	3.40*
Body	2.67	2.47	2.93	2.63	3.10**
Texture	2.60	2.73	3.63**	2.87	4.10**

*Significantly different from the control at 5% level

**Significantly different from the control at 1% level

All the direct acid samples were significantly poorer than the control cheese in all three characteristics. The cultured cottage cheese made from 16 and 20% UF retentates were not significantly different from the control.

It was concluded that UF skim milk retentates containing 16% solids can be used to make cultured cottage cheese of as good quality as can be made from regular skim milk. The yield of such cheese was about 12.4% greater than when made from skim milk, but required the use of 2% concentrated cultures and a setting time of 6-7 hours. The Direct Acid (HCl method) is not recommended for use with UF retentates becasue the cheese quality was distinctly inferior. The use of UF retentates containing 20% solids is not recommended because of a relatively small yield advantage.

References

1. Mattews, M.E., S.E. So, C.H. Amundsen and C.G. Hill Jr. 1976. Cottage cheese from ultrafiltered skim milk. J. Food Sci. 41:619.

COMPARISON OF MILK STARTER, WHEY BASED STARTER AND ACID SET ON THE YIELD, QUALITY AND ECONOMICS OF COTTAGE CHEESE PRODUCTION

W.G. Geilman and C.A. Ernstrom

Considerable confusion exists in the literature concerning the relative advantages of milk starter versus direct acid set (Vitex process) for the production of cottage cheese.

Advertising and industry claims of yield advantages of the direct acid set over cultured cottage cheese were not support by Satterness (Satterness, et al., 1976). The substantial cost of the acidulants used in the direct acid set method coupled with the question of whether the acidulant solids are partly responsible for observed yield increases has stimulated an effort to make a total economic evaluation of these processes. The suitability of using pH controlled whey based starter for cottage cheese manufacture has given a third dimension to this study.

Cottage cheese is being made in 500 lb experimental lots by the 3 above mentioned procedures. A complete mass balance is being made and total costs per pound of finished cottage cheese will be determined for curd adjusted to a constant moisture.

At this time half of the planned 10 replicate batches of cheese have been completed, but the large number of protein, total solids, ash and gluconic acid analyses on the curd, whey and wash waters are not finished.

Some information on setting times seem rather consistent for the experiments that have been completed. The setting times shown on Table I were based on the use of 5% milk starter and 2.4% whey based starter. The two cultured lots were always cut at the AC endpoint which occurred at pH 4.77 $\pm$ .02.

Table I

Trial	Setting Time		
	DA (h:min)	MS (h:min)	WB (h:min)
1	2:20	4:25	4:30
2	2:20	5:20	4:35
3	2:05	4:05	3:35
4	2:05	4:20	4:30
5	2:30	4:00	4:00
Mean	2:16	4:26	4:14

Acidification costs per 1000 pounds of skim milk for the three processes are as follows: milk starter, $3.40; whey starter, $1.22; direct acid, $7.40. When yield figures have been accurately determined the cost per pound of yield will be based on the above figures.

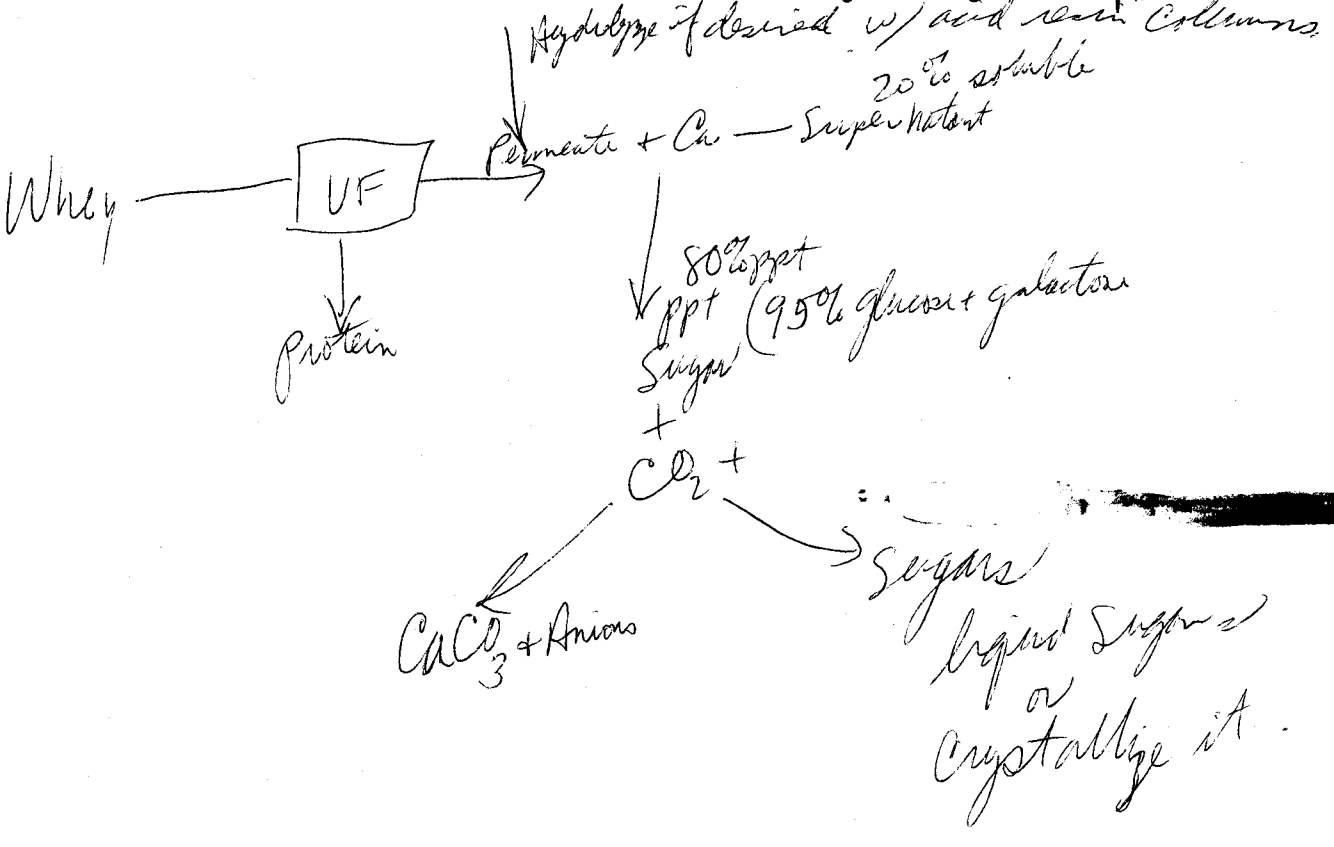
In addition to yield and cost figures the project is set to evaluate quality. Each lot of finished curd will be creamed and graded by a trained panel of 5 cottage cheese judges for specific body and texture characteristics. In addition the samples will be rated by a larger consumer panel on the basis of preference only. Two commercial samples of cottage cheese (one direct acid and one culture) will be included in the taste panel evaluations.

Reference

1. Satterness, D.E., J.G. Parsons, J.H. Marton and K.R. Spurgeon. 1978. YIelds of cottage cheese made with cultures and direct acidification Cultured Dairy Products Journal, Feb. (2)8.

Projects for 1979-80

1. Microstructure of process cheese and its relation to rheological properties. Finish This Year.
2. Use of selected mixed strain lactic cultures in Cheddar cheese plants. Continue.
3. Seasonal variations in the ability of milk and whey to support culture growth. Finish This Year.
4. Use of ultrafiltered whole milk for the production of process cheese base. Continue
5. Comparison of milk starter, whey based starter and acid set on yield, quality and economics of cottage cheese production. Finish This Year.
6. Conversion of whey permeate into an acceptable sugar syrup. New
7. Scale up of UF cottage cheese production. Stephan Process
8. Interaction of lactic cultures during mixed growth. New



PROPOSED BUDGET

1 - Full time research associate	$14,000
5 - 1/2 time research assistantships	20,000
1 - Part time technician	5,000
Equipment purchase and repair	10,000
Milk and chemical supplies	6,000
	$55,000
USU Exp. Station	$20,000
Industry Contributions (Seven participants at $5,000 each)	35,000
	$55,000